Standard

Unit 9

DECIBELS AND VALVES

ACMA Syllabus February 2024

Contents

Decibels 2
Origin 2
Base Levels 4
Amateur radio Applications 4
Equipment 4
Signal Reports. 5
Spurious Emissions Specification 5
Valves 6
Resurgence 9
Fingers Beware 9
Interesting Note 9

 © Jules Workshop 2026

Decibels

The first time most people hear of decibels (dB) is in relation to sound. Looking at a noise chart, traffic is quoted at 70 dB (this really is 70 dB SPL (sound pressure level). I checked with a friend outside the amateur radio hobby, and her interpretation of this 70 dB value is that noise is measured in units of dBs. That is a fair but incorrect assumption.

Most new amateur operators encounter the dB while preparing for their Foundation licence. This is where some confusion can start. How can the measurement of noise be used to also measure electronics such as voltage and amplifier gain? A good question.

Let us look at the dB. Firstly, some very important facts about dBs.

1. The dB is a ratio of one level against a second level. More to come about this.
2. The measuring points for the dB levels must be at the same impedance / resistance. This applies to equipment design. Amateur radio equipment would be 50 Ohms.

Origin

The original measurement unit was the Bel, in honour of Alexander Graham Bell, and was developed by Bell Telephone Laboratories to compare losses in telephony cables in the 1920s.

The unit the Bel was found to be too large so the decibel (dB), meaning one tenth of a Bel, was implemented.

The dB is based on the logarithmic scale so that a large range of ratios can be represented by a convenient number. Example is that 100 dBW is far clearer than "10 billion times greater than one watt".

The decibel is not an SI unit but follows the SI convention where the d is lowercase as deci- and the B is capitalized as it originates from someone’s name. See Lesson 1 on SI units.

 © Jules Workshop 2026

Decibels	Ratios	
	Power	E or I
1	1.2589	1.122
2	1.5849	1.2589
3	1.9953	1.4125
4	2.5119	1.5849
5	3.1623	1.7783
6	3.9811	1.9953
7	5.0119	2.2387
8	6.3006	2.5119
9	7.9433	2.8184
10	10	3.1623
11	12.589	3.5481
12	15.849	3.9811
13	19.953	4.4668
14	25.119	5.0119
15	31.623	5.6231
20	100	10
26	398.11	19.953
30	1000	31.623
40	10000	100
50	10000	316.23
60	1000000	1000
70	10000000	3162.3
80	100000000	10000
90	1000000000	31623
100	10000000000	100000

Figure 3: Decibel Table.

The table above provides a more detailed listing of dB equivalents and demonstrates the benefit of using dB over the longer numbers.

 © Jules Workshop 2026

Base Levels

Initially, I stated that dB is a ratio. There are many dB measurements with prescribed base level reference points. I selected only a few examples, and they are listed in below.

Term	Reference Base
dB SPL	dB SPL (sound pressure level) – approximately the quietest sound a human can hear.
dBV	dB(V_{RMS}) – voltage relative to 1 volt
dBµV	Voltage relative to 1 microvolt
dB(µV/m)	Electric field strength relative to 1 microvolt per metre
dBm	dB(mW) – power relative to 1 milliwatt.
dBW	dB(W) – power relative to 1 watt.
dBk	dB(kW) – power relative to 1 kilowatt.
dBi	dB(isotropic) – the gain of an antenna compared with the gain of an isotropic antenna.
dBd	dB(dipole) – the gain of an antenna compared with the gain a half-wave dipole antenna. 0 dBd = 2.15dBi
dBC	Noise level relative to carrier power in a transmitted signal.

Example of Decibel base levels.

If a gain of 15 dBm was quoted as an example. Then 15 dBm is referenced to 1 milliwatt. A quick scan of the tables above shows that 15 dBm gain is 31 times greater or approximately 31 mW.

Amateur radio Applications

Equipment

TH3 Jnr Yagi	The Yagi is rated as having a gain of 5.8 dBd (avg). This means the ratio between a dipole and the Yagi will provide a gain of 5.8 dB or nearly four times better than a dipole. (dBd is the antenna gain relative to a dipole)
ICOM IC-7300	The receiver has a built-in three-step RF attenuator (6, 12 and 18 dB). This refers to signal voltage levels and means the attenuator can drop the levels by 2, 4 or 8 times.
Kenwood TS-480	Carrier Suppression is more than 40 dB (SSB). This refers to the suppression of the carrier by 100 times.

 © Jules Workshop 2026

Signal Reports.

S9 equals 50 micro volts at the radio's antenna connection.

What is the voltage at the antenna port if the signal is 10 dB over 9?

10dB = 20 x $\log_{10}(\frac{Amplitude\ out}{50\ \mu V}) = 3\ V$

What is the voltage at the antenna port if the signal is 20 dB over 9?

20dB = 20 x $\log_{10}(\frac{Amplitude\ out}{50\ \mu V}) = 10\ V$

What is the voltage at the antenna port if the signal is 40 dB over 9?

40dB = 20 x $\log_{10}(\frac{Amplitude\ out}{50\ \mu V}) = 100\ V$

Spurious Emissions Specification

Less than −50dB (HF bands),

Less than −63dB (50MHz band),

Less than −60dB (70MHz band)

Specification	Drop	Reduced by
Spurious emissions suppression HF Band	-50 dB	316.22 times
Spurious emissions suppression 50 MHz Band	-63 dB	1,412.53 times
Spurious emissions suppression 70 MHz Band	-60 dB	1,000 times

 © Jules Workshop 2026

Valves

JJ Thomson, a scientist, discovered, in 1897, that electrons flowed from the negative terminal (cathode) to the positive terminal (anode) in a vacuum. The transfer of electrons in the vacuum is called “thermal emission”.

In 1904, the English physicist John Ambrose Fleming built the first practical vacuum tube termed the ‘Fleming valve’.

Fleming’s valve could turn radio waves into audible signals but could not amplify them.

De Forest demonstrated that signal amplification is achievable by applying a weak input to the control grid situated between the cathode and anode of the valve.

This is the forerunner of all vacuum tubes, which dominated the electronics industry for 50 years.

In the 1940s, valve experimentation was driven by rapid wartime development for radar, radio, and early computers like Colossus. Thousands of varieties ranged from diodes and triodes, complex pentodes, thyratrons, magnetrons, klystrons, and cathode-ray tubes.

Valves go by various names.

- Valves
- Tubes
- Vacuum tubes
- Thermionic valve
- Bottles

The term ‘valve’ is mostly used in British equipment, and the term ‘tube’ is mostly used in American equipment.

The basis of the valve is that electrons flow from the heated cathode to the anode, which are separated and placed in a vacuum chamber. This is a diode. Now, if you can control or vary the flow of electrons between the cathode and anode, you have an amplifier. Figure 1.

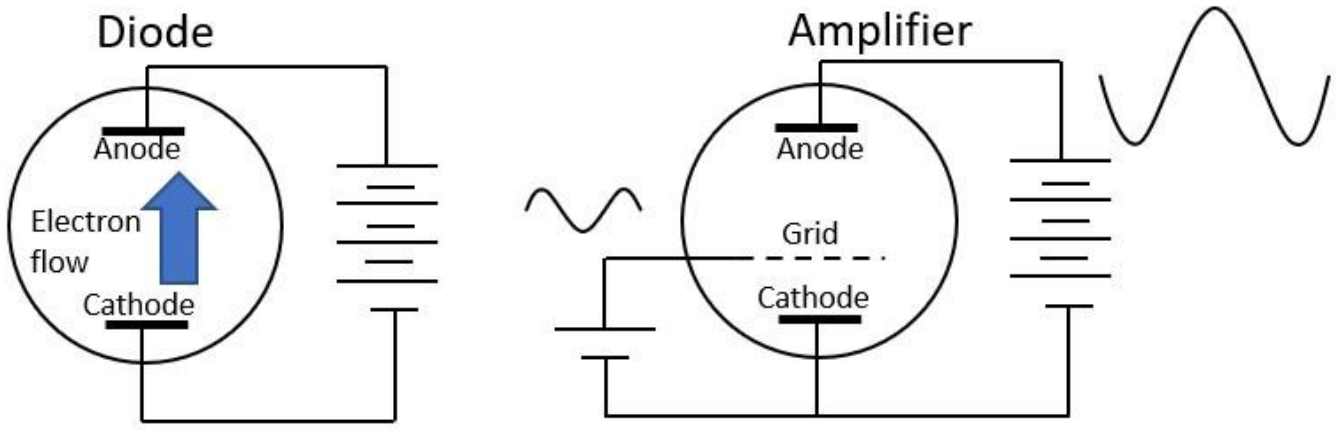

Figure 1: Valve elements.

I pulled three random valves from my old dust covered valve box. Figure 2.

 © Jules Workshop 2026

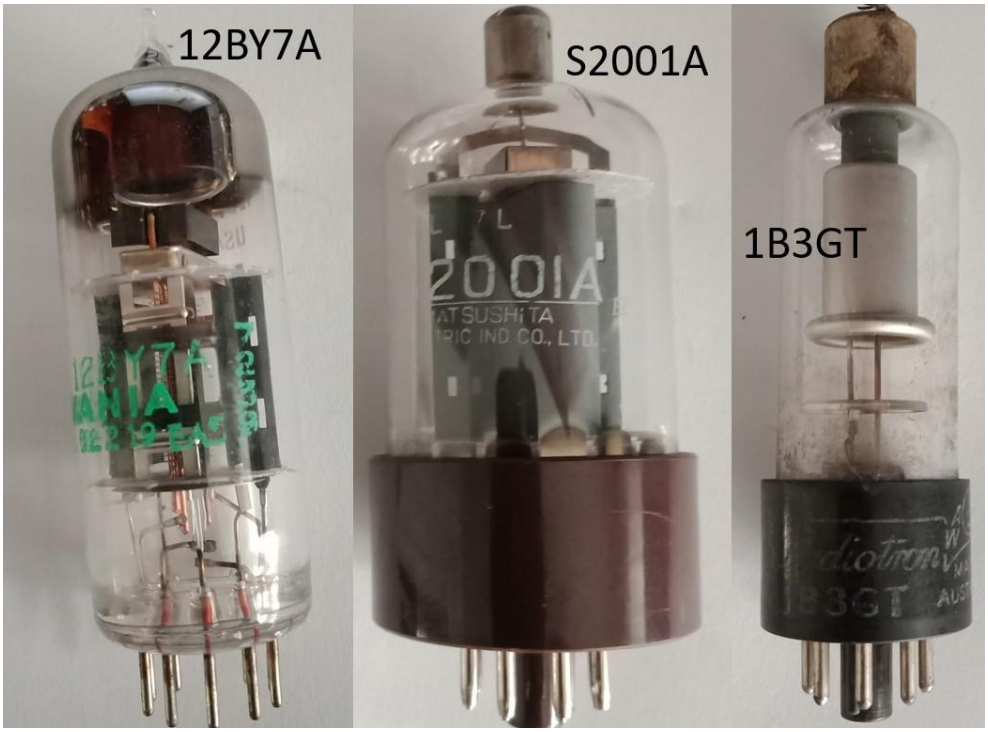

Figure 2: Valves.

In the beginning, vacuum tubes (valves) were triodes, three element valves. These had a cathode, grid, and anode. Valve improvements added additional elements to make a pentode (five element) valve. There are many variations of valves, and these can be found on the internet. The pentode is common in amateur radio uses.

Not all valves are wired or manufactured the same. The material used for the construction of the valve elements also impacts the efficiency and application of the valve.

The elements of a pentode valve are listed below.

- Anode or Plate is the collection point for electrons flowing through the valve.
- Suppression Grid is added to reduce secondary electron emissions from the anode.
- Screen Grid was added to improve the efficiency of triode valves.
- Control Grid, or Grid, controls the flow of electrons from the cathode to the anode.
- Cathode is the originating source of electrons.
- Heater. The Heater, or Filament, is not included in the element count but is required in most valves.

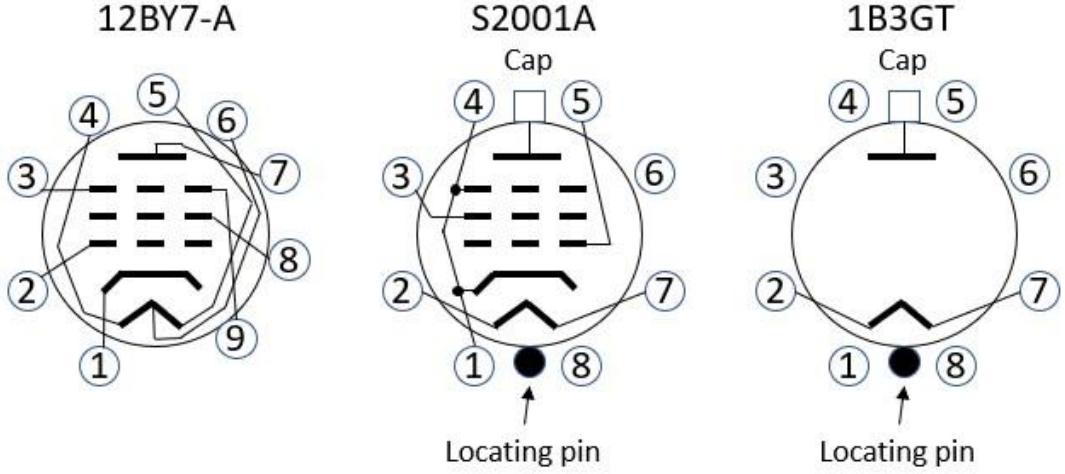

Figure 3: Valve symbols.

 © Jules Workshop 2026

12BY7A

This is a medium-low gain pentode valve used in amplifiers and early television receivers. The valve symbol is shown in Figure 3. The 12BY7A doesn't use a base locating pin to orient the valve correctly. This is achieved by the pin spacing on the base.

- Pin 1 Cathode
- Pin 2 Control grid acts as a gatekeeper to modulate the anode current, allowing small input signals to control a large power output.
- Pin 3 Suppression grid is to suppress secondary electron emissions from the plate—which can cause unwanted dynatron oscillations.
- Pin 4 Heater
- Pin 5 Heater
- Pin 6 Heater tap. Heater centre tap balances the AC voltage supplied to the tubes to reduce hum.
- Pin 7 Anode
- Pin 8 Screen grid is held at a positive DC potential to reduce inter-electrode capacitance (preventing oscillation) and increasing gain and efficiency.
- Pin 9 Same as Pin 3

S2001A or 6146B

This is a common power output pentode valve used in older amateur radio transceivers from Yaesu, Kenwood, Collins, et al.

The S2001A (6146B) features an improved design that allows for higher plate dissipation and can draw more plate current than the original S2001 (6146A).

The S2001A can replace an S2001, however, the final amplifier may require neutralization to prevent oscillations.

The characteristic of the valve depends on the application so consult a datasheet for more information. The valve symbol is shown in Figure 3.

- Pin 1 Cathode and suppression grid
- Pin 2 Heater
- Pin 3 Screen grid
- Pin 4 Same as Pin 1.
- Pin 5 Control grid
- Pin 6 Same as Pin 1.
- Pin 7 Heater
- Pin 8 Not connected.

1B3GT

This is a high voltage diode used in old black and white televisions and now usually found in museums. The valve symbol is shown in Figure 3. I include this valve to demonstrate these components prior to semiconductors.

The peak inverse voltage for this valve is 30,000 V. The Radio Corporation of America (RCA) datasheet for the 1B3GT dated Nov 1949 states that due to the high voltages involved with this diode, it should be shielded as it can produce "soft x-rays" that are not good for one's health.

 © Jules Workshop 2026

Resurgence

The use of the valve has not died out with the introduction of the transistor. Articles suggest a large portion of the current valve production is used in audio and guitar amplifiers. Further details about this can be found at www.effectrode.com/knowledge-base/vacuum-tubes-and-transistors-compared/

Large vacuum tubes are still used in high power amateur and commercial transmitter applications.

Fingers Beware

Caution must be employed when working with vacuum tubes. The cathode is heated to encourage the flow of electrons. Tubes can be hot to touch, 200º C, and the heating elements can be seen to glow. The anode is at a high voltage of around 200 - 700 VDC or higher, and the current flowing though the circuit can be lethal. Capacitors utilised around operating valves can store a charge for a long period. Carefully discharge any exposed anode terminals (on top of the valve) to ground before removing the valve.

Vacuum tubes come in all sizes and shapes and have various names such as vacuum tube, valve, tube and bottle, to name a few. I am sure there are also some derogatory names from people who failed to be careful.

Interesting Note

A neon light is basically a valve diode filled with an inert gas. The colour of the light is determined by the gas used.

Go to Unit 9 Questions.

 © Jules Workshop 2026